# HETA 97–0166–2726
# International Association of Fire Fighters
# Wilmington, Delaware

**Gregory M. Kinnes, M.S., C.I.H., R.S.**

# PREFACE

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# ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Gregory M. Kinnes, of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Calvin K. Cook. Desktop publishing was performed by Nichole Herbert. Review and preparation for printing was performed by Penny Arthur.

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# Health Hazard Evaluation Report 97–0166–2726
# International Association of Fire Fighters
# Wilmington, Delaware
# February 1999

**Gregory M. Kinnes, M.S., C.I.H., R.S.**

## SUMMARY

On April 11, 1997, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the International Association of Fire Fighters (IAFF), on behalf of fire fighters from the City of Wilmington Fire Department (WFD), to assess the incident response procedures used during a fire in a high–rise office building on April 2–3, 1997, in Wilmington, Delaware. The IAFF reported that over 200 fire fighters and other response personnel were involved in the incident.

In response to this request, NIOSH investigators conducted a site visit to the WFD on July 28–29, 1997. In addition to an opening conference with representatives of the WFD and the IAFF, Local 1590, individual private interviews were held with several fire fighters and other members of the WFD who responded to the incident. Several WFD standard operating procedures (SOPs) and other pertinent records were obtained for review. Individual post–incident reports from the line commanders and several other fire fighters were also requested and subsequently reviewed.

The WFD encountered several difficulties while responding to this fire. Fire suppression activities were hampered because the building was a high–rise and because of problems actually locating the fire due to the complex building layout. During the incident, there was confusion regarding actual command responsibility because the WFD's SOPs were apparently not followed. In addition, the WFD did not have a formal Incident Command System (ICS) in place to assist with managing an incident which required the response of all their resources and mutual aid from other fire departments. The WFD's SOP system, according to the information that was reviewed, did not adequately address the several considerations specific to a high–rise situation. These situations include expanding the command structure to accommodate the large number of fire fighters typically required at major high–rise incidents, safety, support functions, lobby and elevator control, stairwell support, etc. In addition, the issue of interagency coordination or mutual aid command procedures was only briefly mentioned in the SOPs. During the incident, the limitations in the SOPs and an apparent absence of any pre–planning for large–scale incidents resulted in a lack of fire fighter accountability, considerable confusion in the incident command and staging areas, problems with the communications system, logistical difficulties, and coordination problems within the WFD and with the responding mutual aid units. In addition, the WFD's current system of equipping fire fighters with self–contained breathing apparatus (SCBA) led to a shortage on–scene. Each WFD fire fighter is assigned an SCBA mask while the fire apparatus is equipped with a set number of SCBA harnesses, air cylinders, and Personal Alert Safety Systems (PASS). As a result, some fire fighters who responded to the general alarm reportedly did not have complete SCBAs to wear. Other problems that were encountered included the equipment incompatibilities between

the WFD and the mutual aid units, the dissemination of information regarding the potential for exposure to hazardous materials such as asbestos and polychlorinated biphenyls (PCBs), and a lack of appropriate decontamination procedures.

On the basis of the information obtained and reviewed during this investigation, the NIOSH investigators were able to identify several limitations that hampered the WFD's response to this high–rise incident. These limitations include the complexity of the building layout and the fact that the building was a high–rise, the lack of a formal ICS and appropriate pre–planning, communication problems during the incident and recall (general alarm) of WFD fire fighters, lack of coordination with fire fighters responding as part of mutual aid, fire fighter accountability, delegation of authority in areas such as incident command, safety, and logistics, confusion in both the incident command and staging area, and the use of SCBAs by the fire fighters. This report summarizes work practices as they affected the health and safety of the fire fighters, including the Incident Command System (ICS) and safety management. This report also discusses decontamination of fire fighter personal protective equipment and provides recommendations based on the findings of this investigation.

Keywords: **SIC 9224** (Fire Protection), fire fighters, firefighters, incident command system, ICS, self–contained breathing apparatus, SCBA, high–rise building.

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# INTRODUCTION

On April 11, 1997, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the International Association of Fire Fighters (IAFF), on behalf of fire fighters from the City of Wilmington Fire Department (WFD), to assess the incident response procedures used during a fire in a high–rise office building on April 2–3, 1997, in Wilmington, Delaware. The IAFF reported that over 200 fire fighters and other response personnel were involved in the incident. The IAFF requested that NIOSH review the response procedures used during this incident and investigate the potential exposures to asbestos and polychlorinated biphenyls (PCBs) that may have occurred, including post–incident decontamination.

In response to this request, NIOSH investigators conducted a site visit to the WFD on July 28–29, 1997. On July 28, an opening conference was held to discuss the incident and the nature of the request with representatives of the WFD and the IAFF, Local 1590. During the remainder of the site visit, individual private interviews were held with several fire fighters and command staff of the WFD who responded to the incident, and copies of several WFD standard operating procedures (SOPs) and other pertinent records were obtained for review. Individual post–incident reports from the line commanders and several other fire fighters were also requested and subsequently reviewed. Since the incident is still under investigation by both the WFD and the Bureau of Alcohol, Tobacco, and Firearms (ATF), transcripts of the radio communications during the incident could not be released for review.

This report summarizes work practices as they affected the health and safety of the fire fighters, including the Incident Command System (ICS) and safety management. This report also discusses decontamination of fire fighter personal protective equipment and provides recommendations based on the findings of this investigation.

# BACKGROUND

The WFD employs approximately 170 uniformed fire fighters, 41 of which are officers, and serves a geographic area of 15.7 square miles with a population of 71,500. The department normally operates 3 shifts (platoons) with 50–55 fire fighters per shift. The WFD has established a minimum operating level of 38 fire fighters per shift. The operations division of the WFD is divided into two fire districts (1 & 2) and an ambulance unit with two contracted ambulances. District 1 serves the area of the city north of 9$^{th}$ Street while the area south of 9$^{th}$ Street is served by District 2. Each of the fire districts is equipped with three engines, one ladder truck, and one battalion chief unit. Fire District 2 additionally houses a heavy duty rescue squad. Each piece of equipment usually carries a 4–person crew.

On April 2, 1997, the WFD responded to a fire at a multi–story building located in the downtown business district of Wilmington, Delaware. The building consists of a 14–story U–shaped structure originally built in 1919 and a 22–story high–rise tower addition completed in 1958 which was erected in the original courtyard (core) area of the building. The building is used primarily for business offices with 201 tenants employing approximately 700 workers. The fire occurred in a file storage room on the 14$^{th}$ floor of the 22–story tower. The room where the fire originated contained numerous boxes of paper files stacked on the floor or placed on shelving constructed mostly of wood. The fire was contained mostly to the 14$^{th}$ floor except through one building chase where the fire extended vertically for four floors.

At 2119 hours (military time), on April 2, 1997, the WFD received a 911 telephone call reporting the fire at the building. The first fire fighters arrived on the scene at 2122 hours. The deputy fire chief arrived on the scene at 2138 and issued a general alarm at 2140 hours. The general alarm recalled all available WFD personnel to respond and designated the incident for mutual aid. The response to the alarms included all the resources of the WFD, including reserve apparatus, and numerous fire fighters and equipment from

surrounding communities responding to the mutual aid request. Over 200 fire fighters responded to this incident. Fire fighting efforts were hampered by the building layout and the intense heat and smoke that was present. Fire fighters had difficulty initially locating the fire primarily due to the building layout. After locating the fire, they were not able to properly ventilate the area to relieve the intense heat and smoke until well into the incident response. Due to the presence of spray–on insulation potentially containing asbestos which was reported by an industrial hygienist retained by the building owner, the fire was declared a hazardous materials incident during the later stages of the fire. The fire was finally declared under control at 0942 on April 3,1997.

# METHODS

NIOSH investigators met with the local IAFF representative and fire chief from the WFD. This meeting was arranged to discuss the incident chronology, the procedures used during the response, and the subsequent actions of the fire department in response to fire fighter concerns regarding possible exposures to asbestos and PCBs. The NIOSH investigators spent additional time during the two days interviewing various fire fighters and command personnel who responded to the incident and reviewing records obtained by the WFD which were related to the incident. These records included the incident chronology report, personnel records, SOPs followed by the WFD, and various other records pertaining to this incident. The NIOSH investigators also requested copies of the command reports that the WFD directed each of the individual apparatus commanders and other individuals who assumed command functions to submit pertaining to their individual commands' activities during the response, and the transcripts of radio communications during the incident. Additional telephone interviews were conducted with WFD personnel not available during our site visit, and with representatives from other agencies regarding their activities during the incident. The individual command reports were received on February 27, 1998, and subsequently reviewed. Since the incident is still under investigation by both the WFD and the ATF, transcripts of the radio communications during the incident could not be released for review. The incident response reports and other pertinent information were used to reconstruct events and procedures used during the incident so that the NIOSH investigators could evaluate the WFD response based on guidelines established by the National Fire Protection Association and the National Fire Service regarding the establishment of an Incident Management System (IMS) and model procedures for high–rise building fire fighting, respectively, and offer appropriate recommendations to the WFD.

# EVALUATION CRITERIA

Fire fighters work in varied and complex environments that increase their risk of on–the–job death and injury. Every day, fire fighters in the United States are injured in the line of duty.[1] According to the Bureau of Labor Statistics (BLS), ninety–four (94) fire fighters died while on duty in 1997.[2] The total of 94 fatalities is the third lowest number recorded in the 20 years that these data have been collected, and is only the fifth time that the total has been less than 100 fatalities.[3] In addition, there were 85,400 fire fighters injured in the line of duty in 1997, a decrease of 2% from the year before.[1] Of these, an estimated 4,750 had to be hospitalized, 12.3% more than were hospitalized the year before, and some were hurt so severely that they can never return to work.[1] Almost half (47.9%) of all fire fighter injuries occurred during fireground operations.[1] The Northeast had the highest fireground injury rate, with 4.7 injuries per 100 fires, which was more than twice the rate for the rest of the country.[1] When compared to data compiled for private industry by the BLS, the incidence of fire fighter job related injury is nearly 6 times that of workers in private industry;

43.1% of fire fighters were injured in 1997 compared to only 7.4% of private industry workers.[4] In terms of severity, fire fighter injuries caused 6,285 lost work hours per 100 workers.[4] Fire fighters face many health hazards, including: inhalation of a wide variety of toxic combustion products; chemical exposures by direct skin and eye contact; physical hazards, including heat, cold, noise, and falling objects; and exposure to carcinogenic chemicals or combustion products. In over 200 residential fires in Boston, air monitoring (which focused on a small fraction of the possible combustion products) found varying air concentrations of carbon monoxide (CO), carbon dioxide ($CO_2$), hydrogen cyanide, benzene, nitrogen dioxide, hydrogen chloride, and acrolein.[5,6] Other toxic components of smoke can include ammonia, acrylonitrile, halogen acids, sulphur dioxide, aldehydes, isocyanates, methylene chloride, particulates, and hydrocarbons.[7,8,9]

Many toxic chemical compounds may be generated and released during fires, and these can vary from fire to fire.[10] Many variables control the resulting byproducts of combustion, the most important being the composition of the burning material.[11,12] Other key factors include the temperature at which pyrolysis or combustion occurs, the concentration of oxygen present, and the efficiency of combustion.[11,12]

Exposures to respiratory irritants such as acrolein, hydrogen chloride, and nitrogen dioxide may lead to acute and chronic respiratory problems. Disability due to pulmonary disease has long been recognized as a potential work–related hazard for fire fighters.[10] There is increasing concern about a fire fighter's exposure to carcinogens released from the combustion of synthetic materials used in building construction.[10] This concern has been compounded by mortality and morbidity studies of fire fighters, which, although they have produced inconsistent evidence, have raised the possibility of increased risks from cardiovascular disease, respiratory disease, and cancers of the nervous, hematopoietic/lymphatic, respiratory, and gastrointestinal systems, which may be attributable to exposures to the components of smoke.[13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28] Several recent studies have suggested an increased risk of brain cancer among Washington fire fighters; brain, prostrate, colon, and lung cancer among Los Angeles fire fighters; and digestive tract cancers.[20,22,24,29] Further studies are needed to better define these risks.

## Incident Command System (ICS)

Management of fire department day–to–day activities is usually vested in a Fire Chief or other titled person who serves as the commander of the fire suppression forces and their activities, including the safety of the fire fighters.[30] To assist in the management (especially in the operation, coordination, and effectiveness) of wide–scale fire suppression activities, a system was developed for controlling personnel, facilities, equipment, and communications. This system is known as the ICS.[31] A further refinement of the ICS by fire service organizations addressed all types of emergency incidents and included performance criteria for the components of a system that incorporated specific safety and health objectives. This has been developed into a nationally recognized standard known as the Incident Management System (IMS).[32] The National Fire Protection Association has documented the consequences of operating without such an IMS which have resulted in numerous deaths and injuries of fire fighters.[32,33] The National Fire Service has also published model procedures for an IMS that is specific for high–rise fire fighting.[34] This publication was the principle resource for this investigation of the WFD's incident response to this high–rise fire, and the basis for many of the recommendations offered at the end of this report.

The IMS requires a plan to coordinate operations with other agencies that have jurisdiction at the incident scene. This plan includes a standard

procedure to designate one incident commander or to establish unified command. The IMS states that this is best accomplished by developing an integrated system in cooperation with all of the agencies that would be expected to work together at routine or large scale incidents. The IMS also provides another approach that may be employed where different agencies have specific jurisdiction over different aspects of an incident. The "lead agency" concept dictates that one agency would assume overall command of the incident, while other agencies fulfill their jurisdictional responsibilities under coordination of the lead agency's incident commander. If plans are not established in advance, the authority for overall command of the incident could be in doubt.

In establishing and utilizing the IMS, the first priority must be life safety.[31,35] The responsibility for this priority issue is that of the officer in command of the emergency incident.[33,35] The incident commander is responsible for the overall safety of all members and all activities occurring at the scene. The Fire Chief, however, bears the ultimate responsibility for the safety and health of all members of the department.

# INCIDENT FINDINGS AND DISCUSSION

The WFD encountered several difficulties while responding to this fire. These included the complexity of the building layout and the apparent lack of pre–planning for this building or high–rise incidents in general, the lack of a formal ICS, communication problems during the recall (general alarm) of WFD fire fighters, lack of coordination with fire fighters responding as part of mutual aid, fire fighter accountability, delegation of authority in areas such as incident command, safety, and logistics, confusion in both the incident command and staging area, and the use of self–contained breathing apparatus (SCBAs) by the fire fighters. There were also concerns about the appropriate hazardous materials (hazmat) response and decontamination procedures based on the possible presence of asbestos and PCBs.

## Building Layout

The high–rise building was built in two phases. The U–shaped structure was constructed in 1919, while the tower was erected in 1958. The original U–shaped structure is 14 stories, constructed of concrete and masonry with a brick veneer exterior, and supported by concrete posts and beams with floors of poured concrete. The roof is a flat corrugated steel deck with the exterior covered by foam insulation and a rolled weather–resistant material. The dimensions of this structure cover approximately 40,000 square feet ($ft^2$). In 1958, the 22–story tower addition was built in the core (open courtyard) of the original U–shaped building and faces north. The tower is built of concrete, masonry, and steel. The exterior surface of this tower consists of metal veneer and glass. The north facade forms one long wall with the ends of the original building, while the south facade of the tower faces a 14–story high, 21 ft x 96 ft opening between the tower and the original building. The bottom of this opening is the roof of the ground floor lobby. The dimensions of the tower cover approximately 10,000 $ft^2$.

The WFD encountered initial difficulties in locating the actual fire due to the complicated building layout. When the first fire fighters arrived on the scene, they were informed that the fire was located on the 14$^{th}$ floor by a security guard. These fire fighters asked the security guard for the elevator service keys and which elevator would take them close to the fire. The security guard directed them to the center elevators serving the tower portion of the structure which they put in “Fire Service” and proceeded to the 10$^{th}$ floor. The fire fighters then proceeded to the 14$^{th}$ floor using the stairwell adjacent to the

elevator bank. On the 14th floor, they encountered light smoke and a set of double doors with smoked stained windows which were extremely hot. At this point, the fire fighters hooked up two 1¾–inch hose lines to the stand pipe located in the stairwell and began their initial attack through the set of double doors. During the initial attack, the fire fighters encountered extreme heat and heavy smoke conditions, but could not visually locate the fire. They made several attempts to advance in a direction where they suspected the fire was located, but were hampered by the heat and smoke. During these attempts, the fire fighters unsuccessfully tried to locate the actual fire and were unable to ventilate the area. While the initial attack was occurring, other WFD units began to arrive at the scene. Several of these WFD units had difficulty locating where the initial attack was occurring. These units reportedly had to use a stairwell to reach the fire floor because the elevators were still on the 10th floor and could not be recalled to the ground floor. In addition, the relief units, both WFD and New Castle county volunteer units, also encountered difficulties locating the actual fire while attempting to establish hose lines to attack the fire from different locations.

These difficulties were primarily due to the building layout including the design of the stairwells and elevator banks. Although the U–shaped structure is considered to have 14 stories, only 13 floors actually encompass the entire square footage of the building. The 14th floor of this building consists of only a penthouse–type structure that is located on the east–side leg of the U–shaped structure. Unlike the 1st through 13th floors, the 14th floor of the U–shaped structure is not conjoined to the 14th floor of the tower. There are four interior stairwells which rise up through the 14–story, original U–shaped structure. These stairwells are located in the northeast, northwest, southeast, and southwest corners of the building. The stairs on the west side of the building went to the roof of the U–shaped building and not the 14th floor of the tower. At the 12th floor, the northwest stairwell transverses to the 22–story tower and begins the stairs serving the remainder of the tower. The southwest stairwell serves only the "U" shaped building and exits to the roof. The stairs on the east side of the building end on the 14th floor in the penthouse–type structure of the U–shaped building. Like the northwest stairwell, the northeast stairwell transverses to the 22–story tower, however, the transverse for this stairwell is located on the 13th floor. The southeast stairwell does not provide any access to the tower and ends on the 14th floor in the penthouse structure. There are three banks of elevators that service the building. Two of these elevator banks service only the original U–shaped structure. One elevator bank is located in the west–side leg of the U–shaped structure which serves up to the 13th floor while the other is located in the east–side leg and serves up to the 14th floor penthouse structure. The other bank of elevators is located on the west side of the tower core and serves up to the 22nd floor. Several fire fighters reported that they did not see any instructional signs regarding stair/elevator destinations which could have prevented confusion.

Several fire fighters reported that they were frequently confused by the building layout. Fire fighters using the northwest and southwest stairwells to reach the fire floor ended up exiting the stairwell onto the roof of the U–shaped structure. They were unaware that the northwest stairwell transverses to the tower on the 12th floor and that the southwest stairwell did not even service the tower portion of the building. Fire fighters using the northeast and southeast stairwells did reach the 14th floor of the U–shaped structure, but had difficulty finding access to the tower portion of the floor. Several supporting units were eventually able to locate the fire and establish a second line of attack. These fire fighters had used the southeast stairwell in an attempt to reach the 15th floor to ventilate above the fire floor. These fire fighters reached the 14th floor penthouse structure of the U–shaped building where this stairwell ended. During the subsequent search of the floor to locate another

stairway that led to the 15th floor, they found one access door to the tower. This door allowed access to a small flight of descending stairs which led to a mechanical room on the 14th floor of the tower through which they located the fire. However, since they had descended a flight of stairs, these fire fighters thought that they were actually on the 13th floor. They were not aware until after the incident that they were fighting the fire on the 14th floor of the tower. It was reported that this led to considerable confusion during the incident. Unlike the 1st thru 13th floors where the U–shaped and tower structures are conjoined, the door that these fire fighters located in the 14th floor was the only access between the penthouse and the tower. In addition, the 14th floors of the original and tower structures were at different levels because, excluding the 14th floor penthouse, the 13th floor was the highest floor in the original structure and thereby had a taller ceiling than the 1st thru 12th floors. The height of the ceiling for the 13th floor and subsequent floors of the tower was the same as the preceding floors. Therefore, the 14th floor penthouse was at a slightly higher level (approximately ½–story) than the 14th floor of the tower.

In addition to the first two lines of attack, a third line of attack was eventually established from the standpipe in the northeast stairwell. The fire was eventually extinguished using these three lines of attack. The use of these three lines was also a concern to the WFD because it created the potentially dangerous situation of opposing lines of attack. However, due to the building layout and access, this was considered the most effective way to attack and extinguish this fire.

## Incident Command System (ICS)

The WFD had not yet established a formal ICS based on the IMS at the time of this fire. However, several fire fighters have received some type of ICS training, and the department has begun moving forward with implementing a formal ICS. Currently, the department's system for incident command consists of established SOPs that address the several aspects contained in a formal ICS. Review of the SOPs currently used by the department indicated that this SOP system addresses command and control procedures, fire communications, alarm levels, staging levels, a contingency recall plan, and several SOPs for high–rise operations. However, the current SOP system, according to the information that was reviewed, does not adequately address the considerations specific to high–rise situations outlined by the NFS.[34] These situations include expanding the command structure to accommodate the large number of fire fighters typically required at major high–rise incidents, support functions, lobby and elevator control, stairwell support, etc. In addition, the issue of interagency coordination or mutual aid command procedures is only briefly mentioned in the SOPs that were reviewed. It is possible that other agencies would not be willing to develop fully integrated IMS with the WFD. In these circumstances, the WFD should utilize its own capabilities to develop and implement an IMS that meets the intent of this standard.

During this incident, officers from the WFD were always in command since the fire was within its jurisdiction. The three lines of attack that were established during the incident became the areas, or sectors, that were used for tactical suppression activities. Two of these areas were commanded by battalion chiefs while the other was commanded by a ranking company officer. Fire fighters from other surrounding New Castle County departments arrived in response to a mutual aid request and were under the command of the WFD. However, it was reported that several fire fighters, both WFD and New Castle County, were confused as to who in the WFD was actually in command. According to the WFD SOPs that were reviewed, the WFD has established a succession of command based on rank. That is, command is initially assumed by the first ranking person/officer on scene. A command post is set up and its location and the

incident commander are identified to dispatch. Command is passed along to the next higher ranking person/officer that arrives including the deputy fire chief and fire chief. At this incident, it appears that the SOPs were not followed because neither the deputy fire chief or the fire chief assumed command when they arrived on–scene due to the complexity of the incident. A battalion chief remained in command throughout the incident even though WFD SOPs dictates that the deputy fire chief should assume command of the incident and then transfer command to the fire chief upon his arrival. According to the IMS, the first–arriving chief officer should assume command of the incident following transfer of command procedures, and later–arriving, higher–ranking chief officers may choose to assume command, or assume advisor positions. Therefore, assumption of command is discretionary for assistant chiefs and the fire chief.[34] Although this progression of command contradicts the SOPs that had already been established by the WFD, this type of command progression is what reportedly occurred during this incident with the deputy fire chief and the fire chief both assuming advisory positions. This was a major reason for much of the confusion that occurred during this incident response. The WFD is currently revising their SOPs to include the aspects of command progression that are dictated by the IMS. Any command assumption or relinquishing must be done deliberately and directly between officers involved to eliminate any guesswork, and any change should be announced over the communications system to dispatch and all personnel on scene. It is critical that fire fighters involved in any incident response always be aware of who is in command. The IMS dictates that the incident commander shall determine the overall strategy for the incident and communicate this strategy to all supervisory levels of the incident management structure. The incident commander should ensure that any change in strategy, including the use or non–use of SOPs, is communicated to all supervisory levels.

## Safety Management and IMS

The IMS encourages the delegation of authority, but not responsibility, for the safety function at an incident to a fire fighter or other competent person, who is specially trained and knowledgeable in safe emergency operations.[31,36] The failure to delegate may cause conflict between the positions of command and safety. IMS guidelines generally recommend that the command officer, who is responsible for managing the incident on the strategic level, establish and operate from a stationary command post as soon as possible after arriving on the scene.[35] In contrast, the delegated safety officer must routinely observe operations at the scene of an incident. This means he must have full authority to move around the incident scene (fire ground) to observe and control safety concerns.[35] Based on the investigation of this incident, there was some confusion as to who was in authority and free to assist the fire fighters in recognizing, evaluating, or controlling fire ground hazards. The WFD does have an assigned safety officer, however, this individual was reportedly not on–scene, but was in the WFD's communication center assisting with the call–back of additional fire fighters to respond to the incident. In this case, an alternate safety officer should have been assigned at the scene to assess hazardous and unsafe situations, and develop measures for assuring personnel safety. This safety officer would also have the emergency authority to stop and/or prevent unsafe acts. If the department safety officer is also routinely responsible for other tasks, an assistant safety officer may need to be designated.

## Command Staff

In addition to the safety officer, the IMS also dictates that other command staff positions should be established to assume responsibility for key positions that are not a part of the line organization. These additional staff positions include an information officer and a liaison

officer. The information officer's function is to develop accurate and complete information regarding the incident cause, size, current situation, resources committed, and other matters of general interest.[34] The information officer will normally be the point of contact for the media and other governmental agencies that desire information directly from the incident. The liaison officer's function is to be a point of contact for representatives from other agencies, such as other fire departments responding to a request for mutual aid. At this type of incident where there was a single command structure, the representatives from assisting agencies would coordinate through the liaison officer. According to several reports, there was confusion regarding the arrival and tracking of fire fighters responding to the mutual aid request and the control of the media present near the incident command post. A liaison officer was not appointed until well into the incident response. A liaison officer should have been assigned soon after the general alarm was called so that this officer would have been able to track the arrival of mutual aid companies, notify the incident commander of available mutual aid units, and direct these units to the staging area for assignment. An information officer would have been in charge of giving all incident reports to the media in addition to keeping them in a designated area away from the incident command post. The use of available police officers to prevent unnecessary persons from entering certain areas and to handle uncooperative persons, including the media, should always be considered.

## Staging and Fire Fighter Accountability

The IMS dictates that fire departments should develop a standard system to manage reserves of personnel and other resources at or near the incident.[32] There were several reported problems with the organization of the staging area and the accountability of fire fighters responding to this incident. The initial staging area was established on the 12th floor and was later moved to the 10th floor. The IMS for high–rise fire fighting dictates that, if conditions allow, the staging area should be established two floors below the fire floor to minimize the time–distance factor.[34] The original staging area was two floors below the fire floor, but it had to be moved down to the 10th floor due the amount of smoke that was present on the 12th floor. There were many reports of confusion in the staging area. For example, although a fire fighter was given command of the staging area, there was reportedly no announcement of the assignment. To complicate the situation, this fire fighter was not an officer and there were several reports of fire fighters not wanting to comply with or questioning his orders. There were reports that at least one WFD officer did not have any fire fighters assigned to him during the incident. Although it was reported that the fire fighter who was assigned command of the staging area did an admirable job, this function should have been performed by a ranking officer, if available, to eliminate any confusion.

Although the WFD has high–visibility vests and other equipment used for quick identification of personnel in command functions, this equipment was reportedly never used. The use of this identification equipment may have helped to reduce the level of confusion by making the commander of the staging area readily identifiable. This equipment would have also aided in the organization of the staging area. There were several reports that the staging area was crowded with both equipment and personnel. Some of the problems encountered included a lack of lighting and the establishment of distinct areas for reserve and expended equipment, reserve personnel, medical treatment, and rehabilitation. Ideally, high–visibility signs should be used to distinguish between the different support areas on the staging floor. Reserve and rehabing personnel should be stationed in separate areas, and a separate stockpile of reserve and expended equipment should be maintained. These stockpiles of equipment should be placed at opposite ends of the staging area with the equipment ready for use maintained closest to

stairwells ascending to the fire floor. The building lighting systems should be used to illuminate the staging area as long as possible. Once this becomes impossible, the use of extension cords or portable generators on the floor below staging should be considered.[34] In addition, plenty of flashlights with spare batteries should be available in the event all other lighting systems fail. Arrangements to take care of the physical needs of the fire fighters should also be a primary consideration. Medical treatment and rehabilitation areas should be established to handle injuries and to provide the personnel with plenty of liquids. Rest rooms for fire fighter use should also be located and opened.

The staging area should be the primary point for all fire department personnel who enter the fire area. According to several accounts, many fire fighters from both the WFD and New Castle County reported directly to areas where fire suppression activities were occurring without previously reporting to either the incident command post or staging area and were thus "free–lancing." There were also reports of fire fighters without partners arriving on the fire floor or at the staging area, and even one report that a company commander knowingly left a fire fighter alone in a stairwell because he became exhausted during the ascent. Fire fighters should always operate using the "buddy system" where teams of at least two fire fighters remain in direct voice or visual contact with each other at all times. Companies that utilize a stair shaft for fire attack should pace themselves while ascending, and take aloft only necessary equipment such as SCBAs, high–rise hose packs with nozzles, forcible entry tools, radios, and stair shaft keys. Although this might not be appropriate in all instances, one company commander, whose company arrived during the initial phases of the incident response, ordered a 2–minute break after every two floors that his team ascended, which allowed all team members to reach the fire floor ($14^{th}$ floor) and still perform effective fire fighting operations.

According to several reports, many of the fire fighters remained in the rotation of suppression activities on the fire floor for long durations while there were reserve fire fighters available for duty in the staging area. In most cases, after fire fighters have used two SCBA cylinders, they should be assigned to a rehabilitation area in staging for a brief rest before returning to any tactical activities.[34] There were reports that fire fighters were typically using three or four cylinders before being sent to staging for a rest. Even then, some of these fire fighters reported being confused as to the actual location of the rehabilitation area. Overall, the fire fighters involved in this incident put forth an aggressive effort to extinguish this fire. However, some fire fighters may have disrupted an appropriate relief cycle by being too aggressive. It was reported that commanders of the three operational areas attempted to use relief cycles to rotate fire fighters in and out of actual fire fighting activities. One commander utilized the rotation of four fire fighting teams to attack the fire. This commander had two hose teams applying water, one emergency team backing them up, with one ready team located in or near the stairwell. With the arrival of more supporting units, this commander was able to have additional ready teams available. As one of the hose teams was relieved to return to the staging area, the emergency team moved up to maintain a hose with the ready team advancing to become the emergency team. Once relieved teams had a chance to replace their air cylinders and rehab, if needed, in the staging area, they would return as one of the ready teams. However, the confusion in communicating with the staging area and the arrival of fire fighters who were "free–lancing" reportedly disrupted the rotation of fire fighting teams by overcrowding the stairwells. The objective of the relief cycle is to maintain a constant application of water on the fire through the constant rotation of fire fighting teams.[34] The coordination of the relief cycle should be the responsibility of the tactical level commanding officer. The staging officer must be informed of the relief cycle and must have companies ready to make reliefs at the needed times. To accomplish

this, the incident commander should be accountable for deployment and tracking of all resources while the staging officer should maintain a complete and accurate record of resource status for personnel accountability. The WFD has already made efforts to improve their system for fire fighter accountability, and has investigated the purchase of different commercial systems for personnel accountability.

## Logistics (Base, Lobby Control, Stairwell Support, and Communications)

During complex incidents, the creation of a logistics group or section provides a support and service mechanism for the operational components involved in the incident. Some of the activities of the logistics group or section would be to establish an incident base, lobby control area, stairwell support function, communications plan, and a plan for medical services including responder rehabilitation. This would allow a structured mechanism for controlling the large numbers of personnel and equipment from the arrival point to their eventual utilization. A formal logistics group or section, commanded by a ranking officer, was apparently never established during this incident.

The base area of a high–rise structural incident serves as an assembly and deployment point from which large quantities of personnel and equipment are distributed. Similar to the staging area inside the building, the base area serves as the primary point outside the structure to which responding resources report and from which resources receive their initial orders for entering the incident.[34] As with the staging area, an incident base commander should be assigned. This commander reports to the logistics section chief or to the incident commander if a logistics section has not been activated. The base area established during this incident was located near the intersection of 10th and Market streets. Even though arriving apparatus were instructed to park at this location, there appeared to be no formal control of the arriving resources or an appointed incident base commander. In addition, there were reports that many fire fighters actually thought that the incident base was the staging area.

The responsibilities for lobby control at a high–rise incident are extensive and should be a priority like staging. A lobby control officer, who reports either to the logistics officer or directly to the incident commander, should be appointed. The lobby control officer is responsible for the control of fire department personnel and civilians entering and exiting the building. All personnel entering or exiting the building should be accounted for by maintaining records that include in and out times and destinations. When directing companies to upper floors, the lobby control officer makes sure that they use the correct stairwell and are carrying additional equipment that may be needed in the staging area. When the elevators are determined to be safe, the lobby control officer shall designate specific elevators to be used and will assign a fire department elevator operator. The lobby control officer is also given the responsibility for notifying the incident commander about some of the important building systems, such as ventilation (Heating, Ventilating, and Air–Conditioning [HVAC]) equipment, public address system, standpipe system, phone system, and alarm system, that affect the fire fighting operation. During this incident, there apparently was no formal lobby control, which may have added to the confusion.

A stairwell support function is implemented when equipment cannot be moved to staging by elevators or when an additional water supply is needed. This operation can consume a large number of personnel, not only for initial set up, but also for relief personnel. The responsibility of stairwell support is the priority transportation of equipment by way of a stairwell to the staging floor. If an auxiliary water supply is required by

way of the stairwell, the officer in charge of stairwell support will coordinate and supervise this effort.[34] During this incident, a formal stairwell support function may have been useful during the early phases of the incident response since elevators were utilized later in the incident.

The communications officer reports to the logistics chief or the incident commander and ensures that an effective communications system is maintained. This includes portable radios, spare batteries, cellular phones, and the building's public address system. The communications officer will also coordinate communication needs with outside agencies. During this incident, there were several reports of communication difficulties both within the WFD and with the responding mutual aid fire departments. The WFD utilizes a 800 megahertz (MHz) communications system with five (5) preset channels. Four are considered operational channels which are monitored in the communications center while the fifth channel is utilized by the WFD fire investigators. Several fire fighters reported that there were excessive communications on the main operational channel (TAC A) while the other three operational channels were underutilized. According to the SOPs that were reviewed, there were apparently no pre–established procedures for the use of the other channels during an incident which involves all of the WFD's resources. In addition, cellular phones or the building's communications system, if one existed, were apparently not utilized during this incident.

The use of specific channels for the different incident functions should be incorporated into the WFD's communications plan. During a response of this magnitude, one channel should be designated only for communications between the incident commander and the actual operational units involved in the fire suppression activities. The other channels should be designated for the other functional entities at the scene. For example, the other three channels could have been designated for communications between the IC and the staging area; between the IC and the logistics functions including the incident base, lobby control, elevator operators, and stairwell support; and between the IC and the emergency medical services. The remaining channel, which is typically used for the fire investigators, could have been designated for emergency use between the communications center and the mutual aid companies that were manning WFD fire stations to provide fire protection coverage for the city while all the WFD units were responding to this incident.

Another communications problem encountered during this incident involved the portable radios utilized by the WFD and the responding mutual aid units. Reportedly, the communications system utilized by the mutual aid companies is used statewide in Delaware, except for the City of Wilmington. Therefore, many of the mutual aid units were not able to communicate with the incident command unless they were assigned to a fire team that included WFD fire fighters. In contrast, incident command was reportedly not able to effectively communicate with the mutual aid units until later in the incident when the liaison officer was given a portable radio which was compatible with the communications system utilized by the responding mutual aid companies.

An effective communications program also involves a system for call–back of fire fighters during a general alarm. During this incident, it was reported that there was considerable confusion regarding the call–back of off–duty fire fighters even though the WFD has an established procedure that is outlined in their SOPs. It was reported that both fire fighters on disability leave, vacation, or already on–duty at the fire scene were called to respond to the incident. This created both confusion at the incident as well as undo concern among some fire fighters' families. According to the SOPs, fire fighters on disability leave or using earned vacation days at the time of an incident are not supposed to respond to a general alarm. In addition, some confusion may have occurred because personnel familiar with the call–back system were not on duty at the time of

the incident. This was the main reason why the WFD's safety officer was performing call–back duties during the incident instead of being on the scene. The program used to train the communications staff needs to be improved to ensure that all personnel can effectively respond to the communications needs required for a large incident.

## Emergency Elevator Use

The IMS procedures for high–rise incidents dictates that fire departments must have SOPs regarding the use of elevators, stair shafts, or combinations of both when ascending to the upper floors during a fire or reported fire operations.[34] The safest method of ascending to the fire floor is to use a stair shaft that accesses the fire floor.[34] However, in some situations, such as extremely tall buildings, this might not be practical, and it may be necessary to explore the use of elevators for fire fighting operations.

Under normal conditions, elevators are the only practical method of moving between floors in a high–rise building. However, under fire conditions, elevator operation can become very erratic and extremely dangerous. In buildings with multiple elevators, all the elevator cars in a bank are usually in a common hoistway.[34] Some high–rise buildings are equipped with low–, medium–, and high–rise bank elevators, also known as spilt bank elevators. As discussed previously, the first ascending team was directed by a security guard to the central bank of elevators which they used to ascend to the 10th floor. They then proceeded using a stairwell to the 14th floor where the fire was reportedly located. This bank of elevators serviced floors 1–22 of the tower portion of the building which included the fire floor. The IMS dictates that fire fighters should not use an elevator in a bank that services the fire floor unless the elevators are determined to be safe.[34] Even when assurances are in place that elevators can safely be used, additional safety features should be employed, such as the use of split–bank elevators that terminate at least five floors below the lowest reported fire floor and the use of only elevators that allow fire fighter service mode.[34] During this incident, the units making the initial ascent should have utilized the stairwells to reach the fire floor. However, this would have most likely meant a longer delay in locating the fire, given the difficulties encountered by the later arriving units who did use the stairwells. Once the actual fire was located, a determination of safe emergency elevator use should have been made. Once elevator use was authorized, only the elevator banks that serviced the original U–shaped structure should have been utilized for fire fighting operations because they did not service the fire floor. The elevator bank located in the west–side leg of the U–shaped structure only serviced up to the 13th floor while the other elevator bank, located in the east–side leg, served up to the 14th floor penthouse structure which was conjoined to the 14th floor of the tower where the fire was actually located.

Elevators should only be used once verified by fire department personnel that the elevators are safe to use during emergency operations.[34] Even when assurances are in place that elevators can safely be used, any additional safety features or procedures should be employed. These include the use of split–bank elevators that terminate at least five (5) floors below the lowest reported fire floor.[34] Only elevators that allow fire fighter service should be used. In addition, all personnel riding in elevator cars should wear full–protective equipment, and have forcible entry tools, a means of communication, an extinguisher, and a knowledgeable fire fighter assigned to operate each elevator car. The elevator operators, in addition to required safety equipment, shall have a portable radio to maintain communications with lobby control.[34] During this incident, fire fighters were not assigned to operate the elevators until well into the incident response. Even then, these operators were reportedly not furnished with any adequate means of communication.

## Respiratory and Personal Protective Equipment (PPE)

There were reports that several fire fighters, including battalion chiefs, did not wear or have access to SCBAs while taking part in fire suppression activities. According to the information gathered during the private interviews, each WFD fire fighter is trained in proper SCBA use, passes a fit–test, and has a personal SCBA mask. However, a complete SCBA consists of a mask, harness, regulator, and air cylinder. The WFD equips each apparatus with the appropriate number of harnesses, regulators, and air cylinders. Therefore, off–duty fire fighters who responded to the general alarm and who did not respond on one of the reserve apparatus were not equipped with a complete SCBA. In the case of the battalion chiefs, it was reported during this investigation that the two command vehicles used by the battalion chiefs were not equipped with the SCBA harnesses, regulators, or air cylinders at the time of this incident. It was also reported that the practice of equipping these command vehicles with SCBAs was eliminated during the 1980s. However, this is disputed by the WFD. The same situation existed with the Personal Alert Safety Systems (PASS) which sound a distinctive audible alarm when either activated manually or automatically if no movement of the fire fighter can be detected in any 30–second period. These devices are typically placed on the SCBA harness, so only fire fighters who responded on the WFD apparatus which were equipped with the SCBA harnesses were also equipped with PASS.

This apparent shortage of fully–equipped SCBAs was reportedly compounded because many of the mutual aid units were equipped with SCBAs from different manufacturers. This contributed to the confusion of the staging area because it was difficult to locate the correct replacement air cylinders for the SCBA that was being worn or the correct SCBAs for masks that a fire fighter was carrying. In addition, it was reported that some WFD fire fighters who were wearing SCBAs with low pressure regulators mistakenly used high pressure air cylinders that were brought by the mutual aid units. This mix–up between low and high pressure air cylinders caused problems because the diaphragm of low pressure regulator can, and reportedly did, rupture when used mistakenly with a high pressure air cylinder. This causes free–flow of air which severely limits the usefulness of a SCBA because each air cylinder will only last a short time. There were also some reports of confusion or problems with compressors to refill the air cylinders. A safety officer would have been able to ensure that all fire fighters were not only properly wearing their SCBAs, but also assist fire fighters in using the appropriate air cylinders for the SCBAs they were wearing. Since the safety officer needs to remain free to move about the incident scene, the safety officer could have worked with logistics in designating an individual to help ensure that there was a sufficient number of filled, spare bottles on the scene. During this incident, it was reported that there were a sufficient number of spare air cylinders available, but that there was considerable confusion created by the unorganized presence of the different types of air cylinders and other SCBA equipment.

## Hazardous Materials

During the course of this incident response, it was discovered that the presence of hazardous materials may be a concern. It was reported that there were several drums on the fire floor and that these drums may have contained waste oil contaminated with PCBs. It was also discovered that the columns, girders, and ceiling areas had been treated with asbestos containing spray–on insulation. This was a source of confusion both during and after the incident response. The presence of asbestos was confirmed during the incident by an industrial hygienist hired by the building owners. However, the presence of PCBs was only suspected and could not be confirmed by the industrial hygienist. The presence of asbestos is not an atypical situation because asbestos is still found in many older buildings. In addition, the proper use of SCBAs during fire suppression and overhaul significantly reduces the risk of

exposure. The concern over PCBs was eventually diminished because their presence was not detected in analytical samples collected at the scene and the potential for any significant exposures was considered minimal. This was originally a concern because there were no material safety data sheets on premises for the drums of waste oil, even though the building management was notified of this during a fire inspection conducted two months prior to the incident. Most of the concerns among the fire fighters seemed to be created by the lack of communication about the presence of hazardous materials and the confusion regarding the proper decontamination of equipment, especially the fire fighters' turnout gear. Several fire fighters were concerned because they thought that they had been exposed to PCBs and requested that the WFD conduct medical monitoring even though the presence of PCBs had not yet been confirmed. In response to the fire fighter concerns, the WFD had one shift of fire fighters monitored for the presence of PCBs in their blood. This monitoring was stopped as soon as PCBs were no longer a concern. However, this fact was never effectively communicated to the fire fighters, and several fire fighters were still concerned because they thought the WFD had ceased the monitoring because the results did not indicate any exposure. This concern existed because the shift that had their blood samples taken was not the shift that was originally on–duty the night of the incident, but had responded to the general alarm. Therefore, fire fighters from this shift would not have had the greatest potential for exposure.

There was also concern regarding the decontamination of turnout gear. The WFD currently does not have a formal hazardous materials response team, but has retained a contractor to respond to hazardous materials incidents. Even though the WFD has a contract with a hazardous materials response team, it was reported that the contractor did not perform any decontamination on–scene, but a building contractor was used to decontaminate turnout gear after most of the fire fighters had returned to their stations or homes. There was concern that the decontamination of the gear was not done properly because there were reports that some fire fighters still found white material lodged in the cuffs and creases of the gear. Fire fighters were also concerned that they were not properly notified that they should have their turn–out gear decontaminated. Many of these concerns could have been alleviated with better communication between the WFD and its fire fighters. A fire fighter education program on the toxicity of various chemicals, including PCBs, would also have been useful.

# CONCLUSIONS AND RECOMMENDATIONS

On the basis of the information obtained and reviewed during this investigation, the NIOSH investigators were able to identify several limitations that hampered the WFD's response to this high–rise incident. These limitations included the complexity of the building layout and the fact that the building was multi–storied, the lack of a formal ICS, communication problems during the incident and recall of WFD fire fighters, lack of coordination with fire fighters responding as part of mutual aid, fire fighter accountability, delegation of authority in areas such as incident command, safety, and logistics, confusion in the both the incident command and staging area, the use of SCBAs by the fire fighters, and the problems involving the presence of hazardous materials.

The following recommendations are based on the findings of this investigation, as well as previous NIOSH investigations pertaining to fire fighting activities, and are offered to help prevent fire fighter injuries.

1. The WFD is beginning to incorporate several aspects of the IMS into their SOPs. The WFD should continue this effort by formally establishing an IMS. This system should be

reviewed and supplemented to take into account potentially complex fire scenes where there are multiple fire companies and equipment, mutual aid responses, and/or multi–jurisdictional elements. This should include a plan to coordinate operations with mutual aid responders and other agencies that have jurisdiction at the incident scene and procedures for creating an appropriate command structure and transfer of command procedures. SOPs should be developed which define the roles and responsibilities for members assigned to the command staff once the appropriate command structure has been established. This should include procedures to delegate logistics and safety officers, create and manage the staging area, and coordinate other support activities. The guidelines published in the National Fire Service's "Model Procedures Guide for High–Rise Fire Fighting" should be incorporated into the WFD's SOPs for high–rise incidents.[34] All personnel must be trained in the IMS in order for them to understand their role in the overall situation as well as the role of others.

2. The positions of command and safety should be separated at complex fire scenes where there are multiple fire companies and equipment, mutual aid responses, or multiple floors in a building covering a large area. Such separation will allow the safety officer to function in a manner consistent with the duties recognized as appropriate and as established by departmental SOPs. The safety officer would be responsible for ensuring the proper use of protective equipment, including SCBAs, by fire fighters involved in all fire suppression activities. If the safety officer is not available, alternative members of the WFD should be trained in safety issues and could assume the role of safety officer at the incident.

3. The WFD should review their current hazard communication program to ensure that emergency response pre–planning has been conducted for all sites, where such pre–planning is warranted, within their jurisdiction. These sites would include all businesses and properties where fire fighting activities would be complex, there is a presence of hazardous materials (i.e., high–rise buildings, shipyards, large industrial complexes, etc.), or there is a potential need for special rescue operations (i.e., schools, nursing homes, hospitals, etc.). The emergency response plans, including a hazardous chemical inventory, must be developed by each site's responsible party and should be reviewed by the WFD. In the case of high–rise buildings, these plans should include accurate floor plans that describe, in detail, stairwell access, split– or common–bank elevators, fire prevention equipment, etc., and list a person or persons familiar with the building to contact in the event of an emergency. Currently, the WFD maintains quick reference reports for various buildings or facilities in the two battalion chiefs' vehicles, but these reportedly do not contain any floor plans. In addition, the WFD should investigate the existence of emergency response plans for sites outside their jurisdiction where there is a probability of receiving a request for mutual aid. These efforts should be coordinated with the fire departments of neighboring communities which have mutual aid agreements with the WFD. The WFD should also share their emergency response plans for sites within the city of Wilmington with the departments that may be called for mutual aid.

4. The WFD should evaluate the procedure used to call back off–duty fire fighters during a general alarm and track their arrival at the incident scene. It was reported that both fire fighters on disability leave, vacation, or already on–duty at the fire scene were called to respond to the incident. Callback could be accomplished from a computerized database that includes such fields as shift (A, B, C) and daily work status (at work, vacation, sick time, disability) to identify exactly who was/was not available. In addition, the program used to train the communications staff should be reviewed to ensure that all staff are appropriately trained in all aspects required during a large commitment of resources.

5. The WFD should conduct periodic training exercises with the surrounding New Castle

County fire departments with which they have mutual aid agreements. These training exercises should be conducted with the intent to eliminate many of the problems encountered during this incident. These problems included incompatible equipment (SCBAs, communications, and hose threads), fire fighter accountability, differences with personnel protective and other equipment, communications difficulties, etc. These exercises should be conducted routinely to simulate different incidents which would require a large commitment of resources.

6. The WFD should review their SOPs to ensure that the issue of elevator use during fire suppression activities is adequately addressed. A department–wide policy, which includes the incorporation of pre–planning information, regarding the use of elevators during fire conditions should be developed and adhered to by all department personnel. All fire fighting personnel should be well trained in the operation of fire fighter service controls on elevator cars. An elevator training program should be incorporated into the present WFD in–service and entry training requirements.

7. Fire fighters operating at emergency incidents must always operate in teams of two or more (buddy system). A buddy system allows two fire fighters to observe each other for signs of medical emergencies and to provide assistance to each other if needed. All fire fighter team members operating in hazardous areas must be in communication with each other and with incident command through visual, audible, physical, electronic, or other means in order to provide assistance in case of emergency. The recent revision of the Occupational Safety and Health Administration (OSHA) respiratory protection regulation (CFR 1910.134) includes these measures designed to protect fire fighters while working inside burning buildings and is referred to as a "double buddy system" or more commonly the *2 in/2–out rule*.[37] This provision also states that at least two fully equipped and trained fire fighters must remain outside the structure to monitor those inside and be prepared to rescue them. In the case of complex fire scenes, the WFD should consider the establishment of a rapid intervention crew (RIC) that is designated to stand–by in a state of readiness to perform rescue efforts if the need arises. During a high–rise fire, this RIC would normally be located in the staging area to facilitate deployment in a timely manner.[34]

8. Inter–departmental communications should be improved to address safety issues and concerns of fire fighters. Shortly after incidents, such as this high–rise fire, a meeting should be held among fire chiefs, incident commanders, safety officers, union officials, and other appropriate personnel to discuss, share, and document information about problems that were encountered. The establishment of a joint management/union safety committee to address these and other fire fighter issues should be considered.

9. The WFD should utilize the nearby training facilities that offer training regarding the implementation of the IMS as well as other pertinent subjects. Some of these facilities include the National Fire Academy, the Philadelphia Fire Academy, and the Delaware State Fire School. It was reported that some WFD personnel have already attended some programs that train individuals to teach training courses at their own departments; however, these individuals are not fully utilized by the WFD. WFD personnel should be encouraged to attend pertinent training courses, and the information learned from these courses should be disseminated to the rest of the department personnel whenever possible. One way of accomplishing this may be to create a liberal leave program for personnel to attend training courses. It was reported that fire fighters who want to attend training courses outside of the department have to do so on their own time. If this is true, the mechanism for training requests and approvals needs to be evaluated so that there is an incentive to attend appropriate training courses.

10. The WFD should also evaluate their in–service training program to ensure that it is adequately preparing fire fighters to respond to various incidents and to use all available equipment. According to some reports from the incident, there were instances where fire fighters were not sure how to properly operate certain newer equipment (i.e., deluge gun). If the WFD has not already appointed one, the WFD should consider appointing a training officer to determine which training would be beneficial to the department, plan any in–service training or joint exercises that are needed, and conduct or assist in these training programs. This officer would also be responsible to determine what outside training activities to attend, select WFD personnel to attend these activities, and facilitate the dissemination of information obtained from these activities to other WFD personnel.

11. The WFD should investigate the mechanism in which fire fighters are assigned SCBAs. Currently, fire fighters are assigned only an SCBA mask. However, a complete SCBA consists of a mask, harness, regulator, and air cylinder. The WFD equips each apparatus with the appropriate number of harnesses, regulators, and air cylinders. Therefore, off–duty fire fighters who responded to the general alarm and who did not respond on one of the reserve apparatus were not equipped with a complete SCBA. In addition, this most likely meant that several of the off–duty fire fighters at the incident were not equipped with PASS devices. The WFD should review their current respiratory protection, personnel safety, and quartermaster or allowance programs to ensure that the PPE needs of all fire fighters are adequately being addressed. The WFD could also consider providing additional SCBAs by including them on the vehicle that brings the reserve air cylinders and the air compressor to the scene.

12. The WFD should develop a strategic plan for the purchase of new personal protective, fire fighting, and communications equipment. Several fire fighters reported that many of the problems encountered during this incident were due to disparities between the equipment used by the New Castle County fire departments that responded to the mutual aid request and the WFD. It was reported that the mutual aid companies had much newer equipment which was not compatible with some of the WFD's equipment. This plan should be developed through a cooperative effort of the fire department, the fire fighters' union, and other appropriate offices within the city government. These differences in equipment should also be considered when conducting mutual aid training exercises. The WFD should also consider establishing a preventative maintenance program for all equipment, including PPE. Turnout gear should be properly cleaned and repaired as needed.

13. To aid in the overall management of the fire scene, and to assist the incident commander and fire fighter teams in recognition and control, personal markings, vests, and signs to ensure positive identification of individuals and areas should be used. These identification aides should be made with fluorescent, reflective, or other high–visibility material and should be affixed to protective coats, helmets, equipment, controlled areas, etc. The WFD reportedly had this type of equipment, but these identification aides were never used during this incident.

14. Procedures concerning on–site rehabilitation of fire fighters should be included in the department's standard operation procedures. These procedures should include guidelines for initiating and enforcing rehabilitation efforts and managing the resources and personnel within the rehabilitation sector. The responsibility for initiating the appropriate rehabilitation efforts, including rest, intake of fluids, and medical checks, should belong to the incident commander. These efforts should take into account the incident size, level of physical exertion, and environmental conditions. The rehabilitation sector should be located in an area outside the operational activity area, where protective equipment and clothing can be safely removed and resources appropriate to

the incident can be employed. Dry PPE, such as boots and gloves, should also be made available.

15. The WFD should review its hazardous materials response program to ensure that it adequately addresses all phases of a hazardous materials incident including the appropriate decontamination of equipment. Since the WFD currently utilizes a contractor for hazardous materials response, the WFD should ensure that the contractor has met the basic minimum elements for establishing a hazardous materials response team as outlined in the National Fire Protection Association (NFPA) Standards 471 and 472.[38,39] The use of a contractor for hazardous materials incidents should not preclude appropriate training and equipment for WFD fire fighting units to handle such incidents. The WFD units would typically arrive on–scene at such incidents before the hazardous materials response team and may perform support activities in the event of a large incident. The WFD should also establish an effective communications program to inform fire fighters when they have been involved in a hazardous materials incident and what post–incident actions they may need to take. The WFD should also ensure that it has appropriate quantities of reserve or replacement equipment, including full sets of turnout gear, in the event that any equipment may need to be temporarily placed out of service.

16. In addition to the general fitness-for-duty medical evaluations (i.e., those outlined in NFPA 1582[40]), fire fighters (as well as other emergency and rescue personnel) who are frequently exposed to hazardous materials during both routine fire fighting and hazardous materials incidents should have a medical surveillance program that addresses such exposures. A NIOSH/OSHA/U.S. Coast Guard/Environmental Protection Agency manual on hazaardous waste site safety and health outlines such a program.[41] To address the overall health of fire fighters, the IAFF and the International Association of Fire Chiefs has also developed a wellness/fitness program for fire fighters.[42]

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